The Energy-Efficiency Gap, Behavioral Energy, and Energy Modeling

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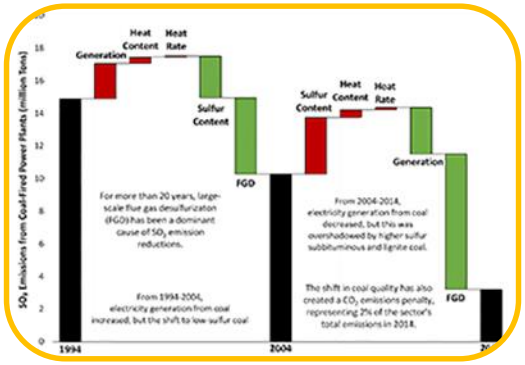
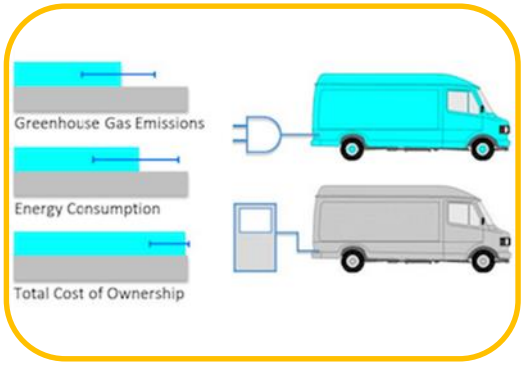
GT Climate and Energy Policy Lab

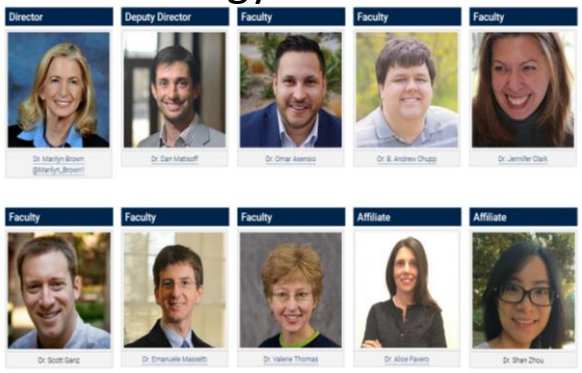
The Low-Income Energy Burdens

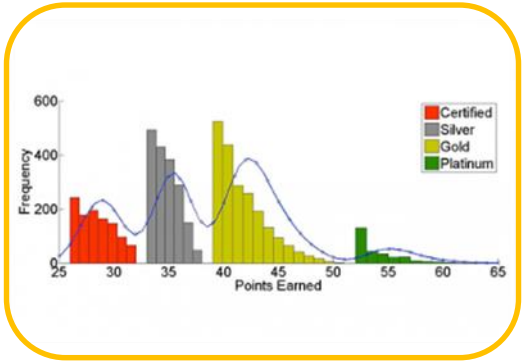


U.S. SO_2 Emissions: Shifting Factors

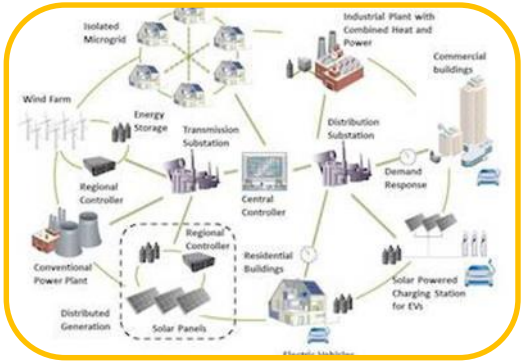


Electric Urban Delivery Trucks

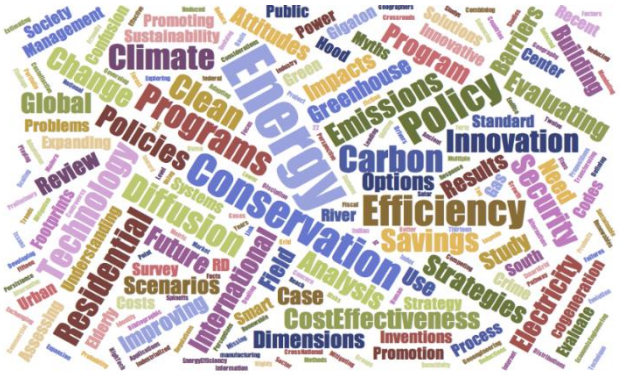




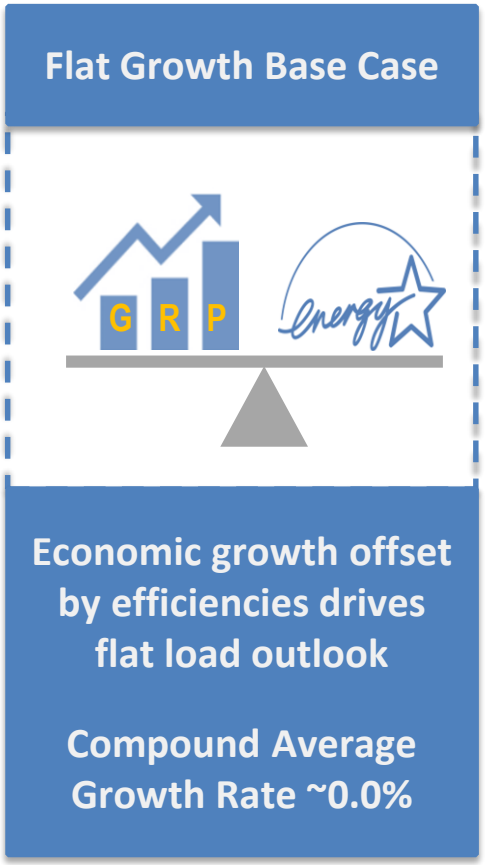
Point Distribution for New LEED Construction



The Emergence of Smart-Grid Policies



Energy Efficiency has Led to Flat Energy Growth in the U.S.



- Energy efficiency is the fastest growing energy resource in the U.S.
- In today's U.S. energy workforce of 6.5 million, 2.25 million work in energy efficiency.

Source: NASEO and EFI. 2018. *U.S. Energy and Employment Report*. www.usenergyjobs.org

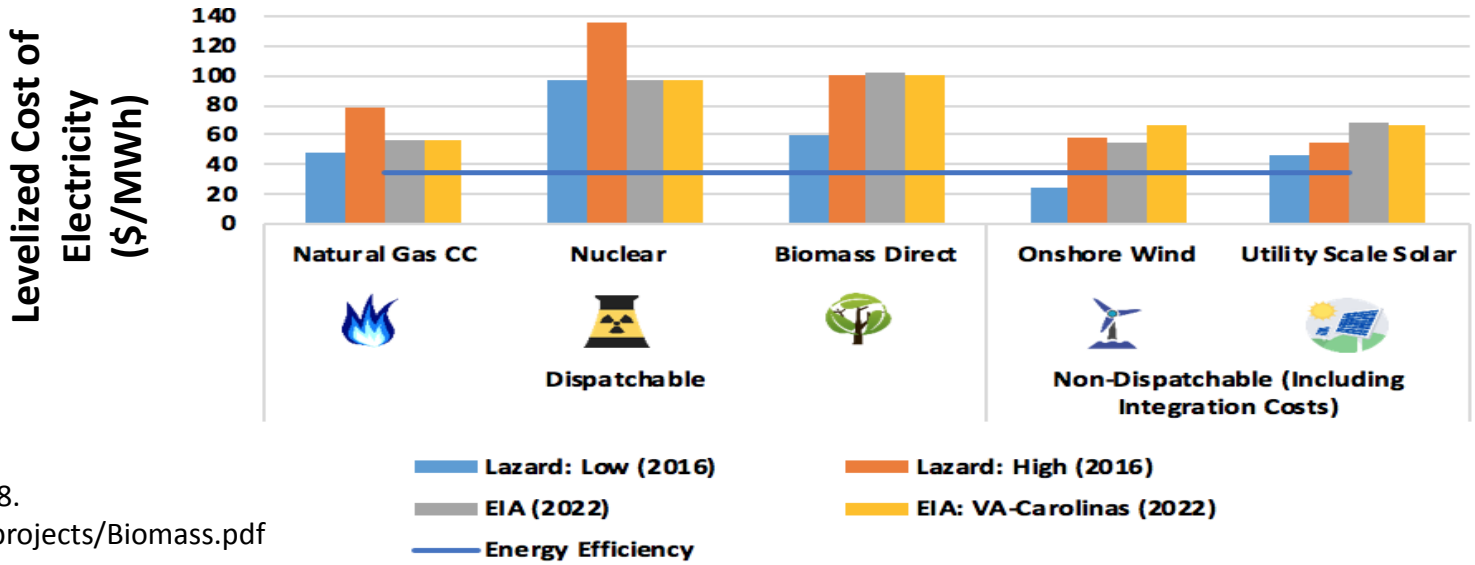
The "Energy-Efficiency Gap" Persists

Energy efficiency gap

From Wikipedia, the free encyclopedia

*This article is about the **energy** efficiency gap.*

Energy efficiency gap refers to the improvement potential of energy efficiency or the difference between the cost-minimizing level of energy efficiency and the level of energy efficiency actually realized. It has attracted considerable attention among energy policy analysts, because its existence suggests that society has forgone cost-effective investments in energy efficiency, even though they could significantly reduce energy consumption at low cost. This term was first "coined" by Eric Hirst and Marilyn Brown in a paper entitled "Closing the Efficiency Gap: Barriers to the Efficient Use of Energy" in 1990.[1]

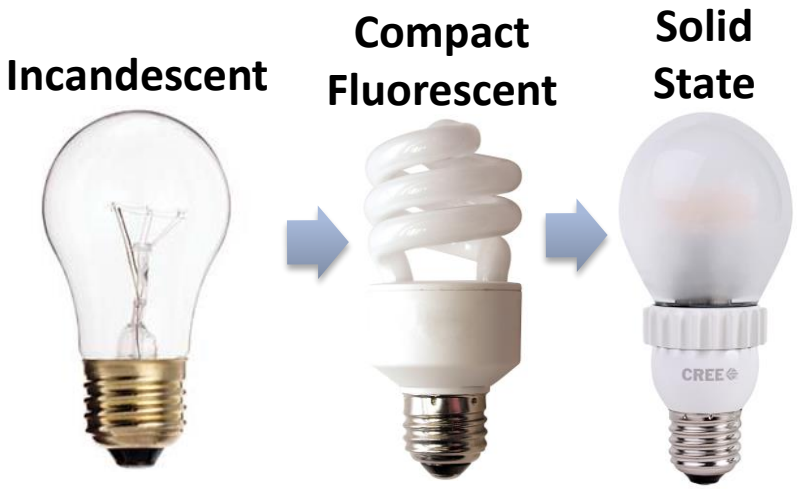


Source: Brown, et al. 2018.
https://cepl.gatech.edu/projects/Biomass.pdf

Energy Efficiency Involves Purchase and Usage Behaviors

- **Energy Efficiency Improvement** – Increasing the services provided per unit of energy consumed.

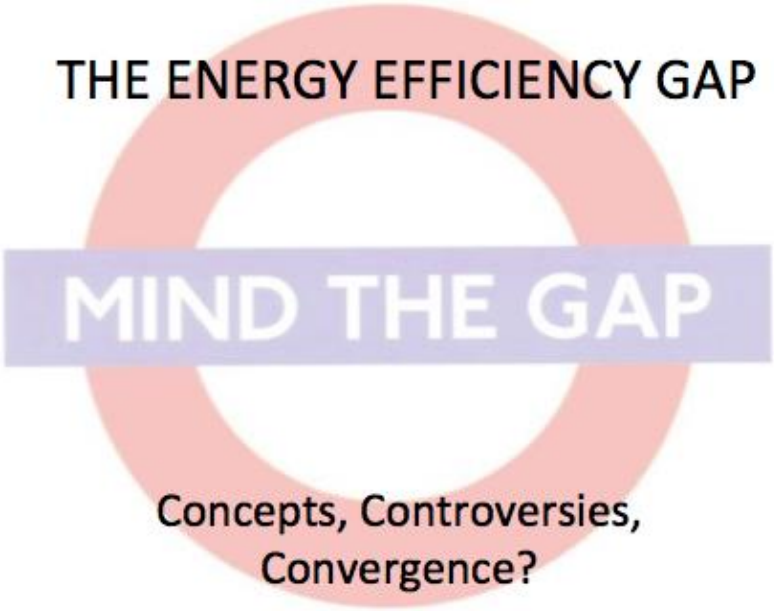
Avoiding the ubiquitous use of fully lit and conditioned spaces



Watts	60	14	11
Lumens per Watt	14	64	84

We have Learned A lot about the Size & Nature of the EE Gap

- How many $20's are on the sidewalk? More than a free lunch?
- Consider some insights about energy behavior and policies:
  - Subsidies
  - Information
  - Regulations



Subsidies: "Favored" Policy but not a Panacea

- While financial subsidies can promote EE, they are not a panacea
- Household responses to identical incentives for improving EE vary by a factor of 10, depending on:
  - incentive design & marketing strategies
  - consumer trust & social norms
  - cognitive effort & rational inattention
  - environmental attitudes
  - time preferences (people with lower discount rates invest more in EE)
  - loss aversion, habit & status quo bias, and more….

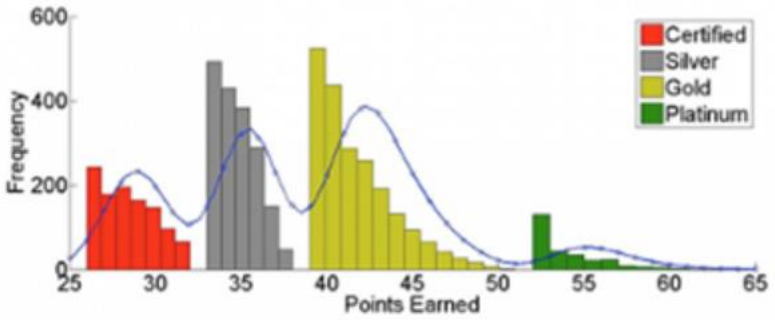
Source: Stern, Paul C., Kathryn B. Janda, Marilyn A. Brown, Linda Steg, Edward L. Vine, and Loren Lutzenhiser. 2016. "Opportunities and insights for Reducing Fossil Fuel Consumption by Households and Organizations" *Nature Energy,* Article number 16043, DOI: 10.1038/NENERGY.2016.43.

Information: "Low-Cost" but Incomplete

Policies like energy benchmarking, labeling, and feedback can:

- Reduce information asymmetries in the marketplace
- Allow real estate markets to operate more efficiently
- Raise the value of high performance buildings and empower tenants
- Labeling programs like LEED can provide investors and customers with an ability to reward reputational value.

- But these are incomplete responses to barriers like the landlord/tenant split incentive, which have been shown in robust research to dissuade renter investments in EE

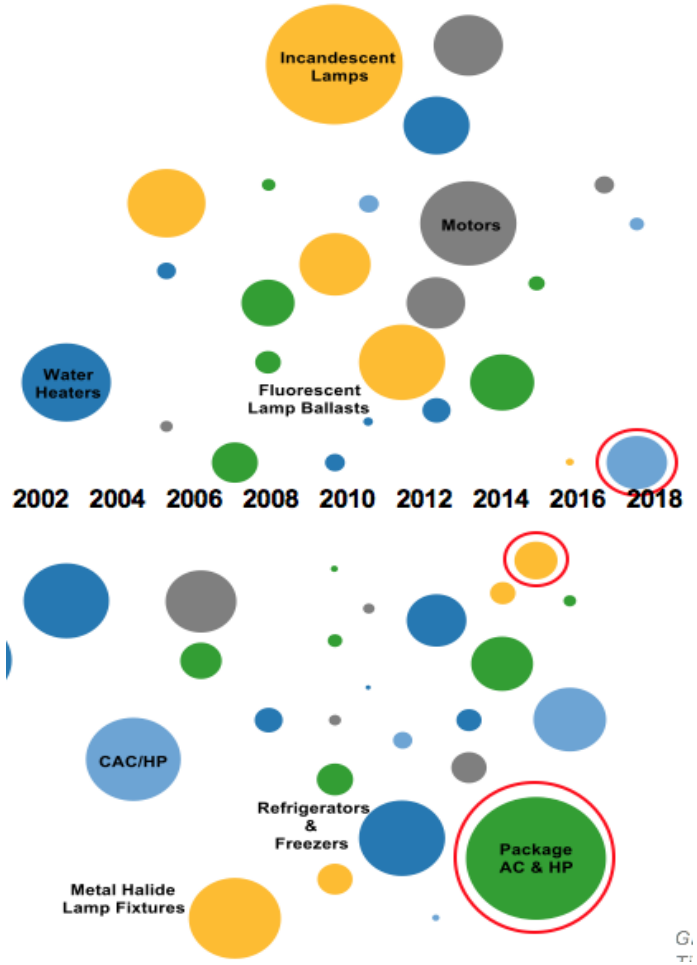


Source: Cox, Matt, Marilyn A. Brown, and Xiaojing Sun. 2013. "Energy Benchmarking of Commercial Buildings: A Low-cost Pathway for Urban Sustainability," *Environmental Research Letters,* Vol. 8, (12 pp).

Energy Performance Standards: Powerful but "Second Best"

New codes and standards have driven down energy demand, especially for lighting and space conditioning.

- But they do not incentivize consumers to reduce their demand for the energy services—e.g., the "Prius effect"
- What about indirect "rebound"—more vacuuming vs a shoe shine?
- How big are the welfare losses?
- How do they compare to the environmental benefits?



Standards: The Biggest Driver of EE in the U.S. Today Source: TVA, 2017

Source: Brown, Marilyn A., Paul Baer, Matt Cox, and Yeong Jae Kim. 2014. "Evaluating the Risks of Alternative Energy Policies: A Case Study of Industrial Energy Efficiency," *Energy Efficiency,* 7(1): 1–22.

What about Organizational Energy Decisions

- Less research has focused on the green purchase behavior of organizations: manufacturers, public institutions, boards of directors, intermediaries, commercial buying units, policymakers, ...
- Yet organizations are responsible for 60% of energy use world wide and they have influential supply chains.
  - ✓ Many profit-making organizations emphasize increasing revenue and meeting regulatory requirements over reducing costs with EE.
  - ✓ Small firms have limited in-house energy expertise; thus business alliances and supply chains are particularly influential.
  - ✓ Mechanisms of clean energy policy diffusion are gaining ground across the EU and U.S.: emulation, coercion, competition, and learning.

Crowded Field of Competing Social Theories

Numerous theories of practice have been used to analyze the greening of consumption

- 27 emphasize beliefs, attitudes and values
  - ✓ Concepts include rational deliberation; expected gains, losses and utility; habit, lifestyle and self-concept; and communication, persuasion, and messaging.
- 23 emphasize contextual factors including social norms
  - ✓ Concepts include social norms and expectations; institutions and social systems; networks and stakeholder influence; copying and conformity; and constraints.
- Perhaps this has undermined confidence in social theory?

Source: Brown, Marilyn A. and Sovacool, Benjamin K. 2017. "Energy Efficiency: The Value-Action Gap", Oxford Handbook of Energy and Society, Oxford University Press, Co-Editors: Debra J. Davidson and Matthias Gross. https://cepl.gatech.edu/publications/pub/5252

Electricity Planning Models Treat Energy Efficiency Simplistically

- Most energy planning models assume an exogenous reduction of energy demand, associated with a step-curve of costs possessing little granularity.
- These modeling platforms do not compete energy supply and demand resource options
  - ✓ Integrated Planning Model (IPM) used by EPA (2015)
  - ✓ the Haiku model used by Resources for the Future
  - ✓ US-REGEN used by the Electric Power Research Institute
  - ✓ FACETS-ELC used by Wright and Kunudia (2016)
  - ✓ MARket ALlocation (MARKAL) model….

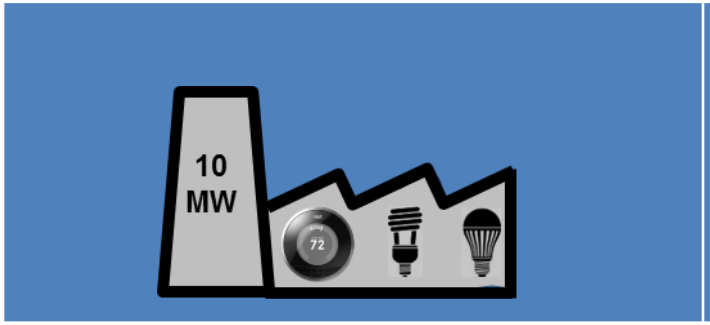
Source: Marilyn A. Brown, Gyungwon Kim, Alexander M. Smith, and Katie Southworth. 2017. "Exploring the Impact of Energy Efficiency as a Carbon Mitigation Strategy in the U.S." *Energy Policy,* 109: 249-259.

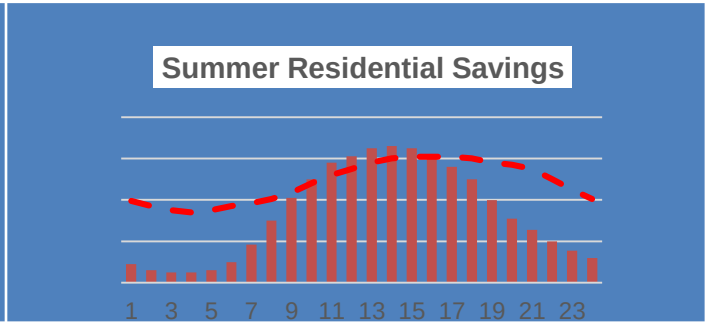
Thus, Nuanced Energy Efficiency Questions are Difficult to Examine

- By misrepresenting energy efficiency as an exogenous resource, possibilities such as the following cannot be explored.
  - ✓ As carbon policies are imposed, EE technologies become more economically attractive & consumers then adopt the technologies in greater numbers.
  - ✓ With increased adoption, high-efficiency demand-side technologies become more economically attractive, leading to increased consumption of EE technologies.
- Models need to allow demand- and supply-side energy resources to compete head-to-head.
- The U.S. National Energy Modeling System does this in an integrated economic-engineering energy model.

Marilyn A. Brown, Gyungwon Kim, Alexander M. Smith, and Katie Southworth. 2017. "Exploring the Impact of Energy Efficiency as a Carbon Mitigation Strategy in the U.S." *Energy Policy,* 109: 249-259.

EE Can Also Be Modeled as Power Plants with Locational Attributes





Building Block Design	Additional Specifications:
Three pricing tiers: 1.16 ¢/kWh to 2.74 ¢/kWh	Limited number of total blocks for each tier
Hourly fixed shape	Risk adjusted for program uncertainty 0% for first five years, 4% annually after year five, capped at 30%
Service life defined by existing programs and industry standards	Growth rate maximum of 25% first five years, 20% next ten, 15% ….
Capacity factors: 65% Residential, 80% Industrial, 79% Commercial	Risk adjusted for LPC delivery risk: 10 % per years first five years, then declining 2% per year

Source: Tennessee Valley Authority (2016) Integrated Resource Plan.

With more Positive Narrative on EE Jobs, Policymakers are Asking More Q's

See: 30-minute CNN discussion of President Trump's Executive Orders: 175,000 "hits"

https://www.facebook.com/cnn/videos/10156318782866509/?hc_ref=NEWSFEED

See: 20-minute "Closer Look" on Georgia Climate Project, one-year after the withdrawal from the Paris Accord

https://www.facebook.com/cnn/videos/10156318782866509/?hc_ref=NEWSFEED

In the Long-Run

The greatest opportunities are likely to lie in:

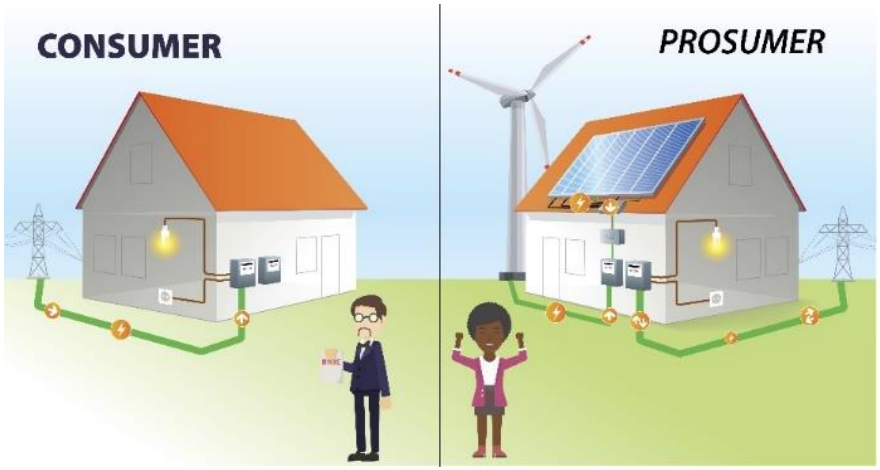
- Technological innovations
- Social movements & new business models
- Infrastructure investments, and
- Cultural changes

To realize bold decarbonization goals will require:

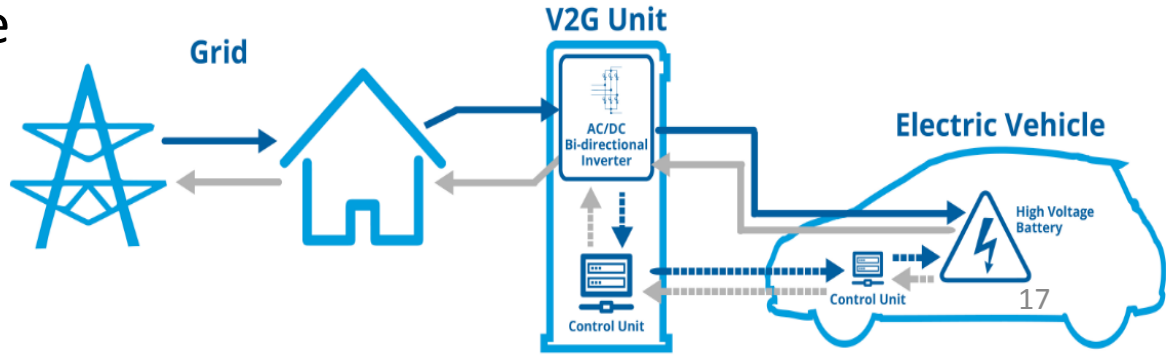
- engagement of the full range of social and economic sciences
- natural sciences, engineering, and planning
- an understanding of how human choices and behaviors are shaped.

The Creation of "Prosumers" and the "Sharing Economy"

- Consumers are becoming producers as well as consumers – "Prosumers"
  - Facilitated by the falling cost of solar panels
  - Home battery systems are on the move
  - Many more EV models available and a growing charging infrastructure



Grid-integrated vehicles could become another form of "prosumerism"



Discussion Questions

- How can we reconcile the array of concepts, frameworks and theoretical platforms?
- How can we expand the examination of energy behavior beyond individuals to include organizations?
- How can new IT and social media mechanisms best be used to expand EE investments?
- Focusing on actions and practices rather than intentions and preferences will avoid pitfalls, but how can we acquire the data?

For More Information

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